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ABSTRACT

This practicum was designed to increase higher level thinking skills of gifted students in primary school. The project sought to retrain students from recalling science information from the textbook to a more challenging and active form of learning through individual projects and small group and large group activities. Students were given instruction in questioning content, they learned to ask and answer higher order questions, they practiced critical thinking skills, they had real-life experiences with science, and practice was given in the use of the scientific method. Of the 26 students, at least 19 showed mastery in each area of instruction. Non-mastery by students in grades 1 and 2 was attributed to lack of experience with content and to developmental level. Appendices contain survey forms, a worksheet for understanding content in science, a worksheet for eliciting answers to higher order questions, and checklists for evaluating critical thinking skills and higher order thinking skills. Another appendix describes over 200 science projects for units on plants, weather, rocks and fossils, animals, energy (heat, light, magnetism), and current topics. (31 references) (Author/JDD)

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Increasing Higher Level Thinking Skills in Science of Gifted Students in Grades 1-4 Through "Hands- on" Activities

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by

Myrna J. Dindial

Cluster 27

A Practicum II Report Presented to the Ed. D. Program
in Early and Middle Childhood
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Education

NOVA UNIVERSITY

1990

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Approved:

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Date of Final Approval of Report

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ABSTRACT

Using "hands-on" Activities in Science to Increase Higher Level Thinking Skills of Gifted Students in the Primary School. Dindial, Myrna J., 1990: Practicum, Nova University, Ed.D. Program in Early and Middle Childhood. Descriptors: Gifted/Science/Elementary/Primary/Curriculum/Problem Solving/ Questioning Techniques/Inquiry/Experiental Learning/Instruction.

This practicum was designed to increase higher level thinking skills of gifted students in the primary school. The main purpose was to retrain students from recalling science information from the textbook to a more challenging and active form of learning through: individual projects, small group and large group activities, questioning skills, critical thinking, and application of science to everyday life.

The writer focused on "hands-on" activities, but combined several interrelated activities in doing so. Students were given instruction in questioning content; they learned to ask and answer higher order questions; they practiced critical thinking skills; they had real-life experiences with science, and practice was given in the use of the scientific method.

It was projected that each of the 26 students would achieve mastery of objectives. Nineteen students showed mastery of explanation and understanding of content. Non-mastery by students in grades 1 and 2 is attributed to lack of experience with content and developmental level. All students mastered answering to higher order questions; more time was spent teaching and practicing this skill. Twenty one students mastered critical thinking skills. Non-mastery by grades 1 and 2 is due to developmental level and lack of experience with the content. All students mastered relevancy of science to everyday life as they had direct meaningful experiences with the material. Nineteen students mastered the use of the scientific method. Non-mastery by grades 1 and 2 is again attributed to developmental level.

CHAPTER I

INTRODUCTION

Description of Work Setting and Community

The public school in which this practicum was implemented is essentially a rural community situated on the edge of a university-centered town. The community is dependent on the nearby university for employment while a large part of the population is engaged in agriculture. There was a steady increase in population growth because the economic landscape is changing from agriculture to industry.

Because of the many interesting features of the community, people prefer to live here rather than in the city. The landscape is undulating with many lakes and rivers offering the tourists a chance to fish, canoe, and hunt. Once a year, all businesses in the area take part in a promotion campaign in the form of a fair to raise money to aid the expansion of the community. As a result many new housing projects have since developed, thus increasing job opportunities, while industries have also mushroomed overnight.

Job availability here and at the nearby university brought a stream of upper middle-class families into the

area, adding to the already existing large middle and lower class population. The ethnic distribution of the population was 70% white and 30% black. Many of the school children were experiencing for the first time the public school environment because they moved from private city schools to the rural community where the only private schools were daycare centers.

With the new influx of people in the community, the school population had grown and had changed in its socio-economic structure. Large tracts of farm land were purchased by the middle class newcomers and turned into residential lots. Shopping centers were built to accommodate the increasing population, and the existing community.

The community prided itself on being once the main city of the county and many of the old buildings were designed with ornate architecture as the old and the new designs present an interesting link between the past and the present. County planners envisioned a continuing pattern of growth in population and expanding industry, and were in the process of improving the highway system that led into and out of the city. The county acquired additional lands for building more schools, and expansion of programs for the existing schools, were already in progress.

Writer's Work Setting and Role

The public co-educational primary school in which the practicum was conducted was situated on a 20-acre campus. The complex consisted of one main building and 9 portables which were brought in to accommodate the growing school population. The institution housed students from Headstart, a pre-school Compensatory Education Program, to grade 4.

The student population was 960 with an ethnic distribution of 70% white, 28% black, and 2% of mixed ethnic origin. Students were from upper-middle, middle, and lower socio-economic classes. The school offered basic education for students from kindergarten to grade 4, compensatory education programs, and Chapter 1 classes for grade 1 students. Exceptional Student Education was offered for the gifted, emotionally handicapped, slow learner, and students with speech defects.

There were 1 Headstart class, 8 kindergarten classes, 9 grade 1 classes, 7 grade 2 classes, 6 grade 3 classes, and 5 grade 4 classes. There was one class each for the gifted, emotionally handicapped, and slow learners. All Exceptional Education classes were resource-based. Because of the large student population, there were 2 teachers each for music, physical education, and art. The school was operated with the help of administrative, instructional,

clerical, custodial, and food services staffs.

The academic staff was composed of 47 teachers who were in racial proportion to the student population, and teachers were certified in their respective areas of instruction. There were one principal, a senior mistress or vice-principal, curriculum specialist, counselor, librarian, 3 secretaries, a custodial staff of 6, and a food service staff of 6. In addition, there were teachers' aides, clerical aides, guidance clerks, and lunchroom aides. Volunteers helped in all areas. Because of the proximity of the school to the university, student interns and student observers were assigned to the school on a regular basis.

All classrooms were self-contained except for those serving special education, art, music, and physical education. The fourth-grade classes were departmentalized into the teaching areas of math, science, language arts, reading, and social studies. Faculty turnover was low. Instructional programs provided for the academics, arts, and athletics. The school's academic programs were especially geared to academic and developmental tracks so that children moved from one track to another or were cross grouped in classes. The librarian taught library skills to each class once a week.

Resource teachers helped in all areas of the curriculum, especially during art shows, science fairs, and social science

fairs. In-service programs were held regularly in all areas of instruction as textbooks and teaching practices change.

The writer's responsibility was that of teacher of gifted education. The writer worked directly with classroom teachers, parents, students, and other resource teachers to ensure the smooth working of the day-to-day activities of the class. Responsibilities of this position included staffing students into the gifted program; writing and reviewing an Individual Education Plan for each student; setting up conferences with parents, counselor, principal, and classroom teachers; planning and executing the curriculum for the gifted; making formal evaluations every six weeks, and sending out a monthly news letter for each grade level.

The writer held weekly meetings with all regular classroom teachers of the gifted students, by grade, to discuss the progress of each child. The writer taught math and science to gifted students in grade 4, and computer programing, problem solving, creative expression, and science to gifted students in grades 1-3.

The writer's educational background included an undergraduate degree in elementary education, a post graduate diploma in education, and a master of science in computer education. The writer was certified in the areas of gifted education,

early childhood, elementary, geography, and English. The writer taught gifted education for the past 8 years.

The writer worked for 15 years teaching math, English, and geography to grades 9 through 13, in schools out of the United States. The writer trained Peace Corps students in developing culture-oriented programs, and taught music on a private basis for 10 years. The writer served on the Academic Board for Roman Catholic Schools for 3 years.

CHAPTER II

STUDY OF THE PROBLEM

Problem Description

In the primary school in which this practicum was conducted, science was considered as important as reading and math. Although its importance was stressed the writer observed several problems in science among gifted students in grades 1-4.

Some students in grades 1-4 found it difficult to effectively explain the science content in the text. They seemed very capable of answering tests given at the end of chapters where answers required matching, filling in blanks, unscrambling words, and naming pictures. When they were asked to explain the meaning of the content and concepts orally, they were unable to do so effectively. It was even more difficult for them to explain the content and concepts in short essay-type answers.

Students were able to answer only in the content mode. They were most comfortable with answering questions which required the mere regurgitation of information. Recalling information comes very easily for the gifted. Many of these students read widely and are avid consumers of

information. Students were unable to see the various angles of a question. They needed to be more curious about the world around them.

Students did not question the subject matter in the science text. They did not interact with the material, but rather accepted it passively as they were not trained to question.

These students were unable to relate science to everyday life. They seemed unable to take new ideas learned in science and apply them to their daily activities. Students were not trained in the application of the content they learned.

The scientific process requires a definite sequence. It appeared that students did not use this process, nor did they use it consistently or regularly to carry out their experiments. They were therefore lacking the independence to do experiments on their own or on a group basis. The problem was that students were taught science through the use of the textbook method only, and as a result, were not exposed to the scientific process which involves higher levels of thinking skills.

Documentation of the Problem

In order to document this problem, the writer did a survey of the types of instructional methods used in

the teaching of science. (see Table 1). Twenty-three teachers out of 31 teachers surveyed used the traditional textbook method. Two out of the six teachers who used the "hands-on" method, used neatly packaged science kits. The other four teachers explained that they did demonstrations rather than the "hands-on" method.

In order to document the problem from the students' point of view, a survey was given to the students to determine if the problem was more accentuated in special areas of the science curriculum. Out of 16 gifted students surveyed, 13 students demonstrated that science fairs, experiments, current science events, field trips, and science grouping in classes, were lacking. (see Table 2).

In individual interviews with the supervisor of science instruction, the principal, and members of the science committee concerning the use of "hands-on" activities, the "hands-on" method was unanimously applauded as this method would take the students through a more meaningful way of learning their science.

Table 1

Survey of Two Methods of Teaching Science by Grade Level

Grade Level	Traditional Method	Activity-Based Method
Kindergarten	6	2
1	6	2
2	6	1
3	5	1
4	0	2*

N = 31

* Grade 4 is departmentalized with 2 teachers for science. The SCIS kits are used.

The survey revealed that 23 out of 31 of the teachers surveyed used the traditional method of teaching science. Four of the teachers who said that they used the activity-based method, stated that they really demonstrated the experiments; children were not actively involved.

Table 2

Results of Survey From Students on Regular Classroom Science Activities

Activities	Number of Times Activities Were Experienced			
	0	1	2	3
Science experiments	13	1	2	0
Science fairs	16	0	0	0
Field trips	13	1	2	0
Points on field trip	12	2	2	0
Guest speakers	11	2	3	0
Current events	14	1	1	0
Children asked questions	12	2	2	0
Science homework	10	4	2	0
Science groups	15	1	0	0
Films/slides/documentaries	10	1	5	0

Number of children surveyed = 16

Science fairs, science groups, current science events, science experiments, and field trips appear to be lacking greatly in the science programs.

Causative Analysis

The problem of gifted students not using higher levels of thinking skills in science may have stemmed from many causes. One cause of the problem of students who found it difficult to explain the science content in the text may have been that they had for too long been passive learners. The time allotted to the teaching of science is 35 minutes per class period. It was evident that there was not much time to teach children to explain certain aspects of the text which they read. The types of questions asked in each section of the text did not warrent oral or written explanation of content. Students were not trained in the art of explaining.

The fact that children were only able to answer in the content mode, is a carry-over from a traditional method of teaching. Since chapter tests require recall of information taught, it could have been possible that the length of class periods did not allow for lengthy questioning. The teaching of discourse is time consuming. In a survey (see Table 2), only 4 out of 16 students asked questions in regular classroom science classes for the week. Children were not encouraged to be curious about the world around them.

Students did not question the subject matter in the texts. If they were exposed to other sources as supplements to the texts, they would have seen added information

which would have caused them to question. Maybe teachers did not model the questioning of materials.

One of the reasons why students were unable to relate science to everyday life was that the teaching of science is text-book based. Children were not actively involved in sciencing so that they were unable to apply what they learned in science to their daily lives, as in the kitchen or garden. Students were not awakened to the new outlook of science. Their minds were not awakened.

The scientific method is one of the better methods for developing higher levels of thinking skills. Students were not taught this process as evidenced in the survey (see Table 1). Students did not use this process consistently to reap the benefits of its all encompassing thinking skills.

The Relationship of the Problem to the Literature

In order to help solve the problem of increasing higher level thinking skills of gifted students in science from grades 1-4 using a "hands-on" approach, it was necessary to review the literature to see what researchers have done on the topic. Penick and Yager (1983) believed that student-to-student interaction, small cooperative work groups, and attempts to use alternative approaches to attain educational goals can be useful in improving thinking skills.

Washton (1976) surveyed principals and teachers as to areas of importance in a science program. The results revealed that critical thinking skills, curiosity, and problem-solving skills were most important. He affirmed Piaget's aims of education as an important component of developing higher levels of thinking skills, namely that teachers should try to develop students' thinking so that they learn to think critically, verify, create, invent, and instill in them the motivation to do new things.

Guided inquiry was suggested by Orlich (1980) as the best method to develop thinking processes, because activity oriented science activities allow students to conduct laboratory experiments that help develop effective reasoning. He believed that guided inquiry makes students familiar with the very methods used by real scientists

in their daily lives. His approach to increasing higher level thinking skills was that students should have direct experiences in science, and teachers should make use of questioning skills while using the expository technique. Shymansky, Kyle, and Alport (1983) found that the main difference between the activity-based method and the traditional textbook method was the number of high level questions asked during experimenting.

Scobee (1983) surveyed highly successful space scientists as to what was their most important science experiences in school. The survey showed that "hands-on" activities and teachers challenging their thinking were most important. Scobee identified active learning as one of the characteristic traits of gifted students. He cited traits of the gifted as superior concentration skills, field independence, reflection, internal locus of control, and persistence.

Martin (1988) pointed out that there is a great deal of concern for maintaining children's curiosity about how the world works as it is difficult to motivate students or use discovery learning when the school environment does not demand a high level of predictability, except for getting a passing grade. He gave some useful steps to follow in problem solving: define the problem; gather information; use given information that will help solve the problem; discuss similar problems experienced, and

how they were solved; and identify and discuss possible problems which might occur in the future.

Martin continued to give some useful advice on questioning techniques, emphasizing that the structure and nature of the questioning sequence was important. He advised that questioning follow the steps of: students volunteering or naming a problem; teacher elaborating with a lot of factual information; teacher following up with a discussion of children's own experiences; and teacher then proceeding with hypothetical problems. Martin highlighted that both teachers' questions and children's questions reveal two domains of thinking - 'everyday and schooled.'

Petry (1980) enumerated some of the advantages students gain when 'sciencing' as:

> They learn to describe an object or event; present information systematically; write concisely and clearly; record events chronologically; combine recalled experiences, observations, and reading to infer their own point of view; communicate the same information in a variety of ways; form an opinion and support it logically; explain a process; include appropriate details; and, perceive relationships among several ideas. (p. 2)

Petry affirmed that individual as well as group work

should be encouraged, while teachers should have high expectations of students and maintain an appropriate developmental level. Focus should be on processes. Petry gave some steps on how to proceed with "hands-on" activities. She suggested that teachers should find out what students already know about a topic, and build a list of information. Together, students should categorize the information and save it for later as the process will help concept formation and generalization. The teacher should then move to "open-inquiry" by providing materials through which the students will arrive at inferences on their own. After "hands-on" activities, children would compare the results with the information they categorized.

Barstow and Roby (1980) concluded from their program that the strategies which emphasized and developed high level thinking skills were those emphasizing creative expression and problem solving, and those involving individual activities and independent projects. Dukleberger (1985) concluded from his study in which elementary science teachers, principals, and supervisors were questioned as to the key factors in an elementary science program, that, there were three vital factors. These factors were that there should be "hands-on" activities in nature; concepts should be appropriate for the developmental level of the child; and teachers should make extensive use of processes. Barstow and Roby (1980), and Dukleberger (1985) together emphasized

that it was not as important what to teach at which grade level but rather to match the process to the developmental levels. Then topics should be chosen to match processes and levels.

Egan (1975) states that there is a need to promote questions which develop high-level thinking. He continues that although there has been half a century of evidence which demonstrates that divergent thinking is superior to convergent thinking, there has been little change in the number of recall questions used by teachers. Egan advocates that the very processes used in discovery learning are those promoted by the use of high level thinking skills for they require students to extend knowledge, deepen understanding, and gain added competence in the structuring of a response. He continued that high level questioning helps to further challenge and motivate students to make inferences, analyze concepts, and synthesize ideas.

Keating's study, cited in Cohen (1979) confirms that "brightness as measured by psychometric testing implies developmental precocity in reasoning." (p. 317) He adds that students with high scores on these tests are not just good "test-takers' but are precocious in intellectual development. Keating argues that since Piaget's theory is that cognitive development proceeds as the organism interacts with the environment, the brighter child would

be at an advantage to move through the stages more quickly.

Howe and Mierzwa (1977) stated that "one of the primary aims of science education is the promotion of the growth of logical thinking; the shift from content acquisition to use of science processes" (p.467). They investigated the effect of instructional classroom exercises in increasing logical thought. The results indicated an increase in performance levels and were attributed to the effects of task instruction and concept-based instruction. The focus of this instruction was the development of logical thinking in low-income students in urban schools at the junior high school level.

Linn and Thier (1975) did experimental research using the Science Curriculum Improvement Study (SCIS) for the development of logical thought in fifth and eight grade students. SCIC is a "hands-on" curriculum with project materials. The results of the research showed that the fifth graders who were in the experimental group were near to the eight graders in formal thinking at the end of the study. They found that the SCIS program was geared to the development of children with differing abilities while it encouraged investigation, a variety of responses, and opportunities for experimentation and choices of problems and materials.

Piaget (1958) explained that formal thought is

distinguished by an exchange between "reality" and "possibility" in the individual's approach to a problem. Piaget stated that the concrete thinker is interested in the "reality" of a situation, that is the way the actual experiment was done; while the formal thinker concerns himself with the "possibilities" inherent in an experiment. The formal thinker seeks other possible experiments to verify an hypothesis.

Joyce and Weil (1972) used a Developmental Model in order to encourage logical thinking in low socioeconomic students. In this model there were clear definitions of terms, the making of inferences, opportunities to interact and exchange points of view, provision of materials, and opportunities to ask questions which facilitated conflict resolution. The Developmental Model included demonstrations, student experiments, small-group discussion, and questioning. Discussion and questions were related to situations which were familiar; experiments performed by the students, and events which were personally experienced by the students. There was cognitive conflict which is an increased ability for logical thought. The findings suggested that classroom based instruction using the Developmental Model favorably impact on the development of logical thinking.

Willson (1973) researched the relationship between the levels of questioning used by teachers and those used

by the students. He also wanted to determine whether thinking levels of teachers increased with an increase in levels of thinking used by students. He concluded that the level of questioning by the teacher will be reflected by the level at which students respond to questions. Willson also found that by increasing students' awareness to the kind of questions which they ask and by "redirecting questions toward higher levels.....teachers can raise the pupils' level of thinking."

Gall (1984) indicated in his study that higher order questions require students to exercise independent thinking. Prediction, relation, inference, and analysis are associated with higher order questions. Winnie (1974) stated that higher order questions require students "to mentally manipulate bits of information previously learned to create an answer, or to support an answer with logically reasoned evidence" (p. 14).

Wasserman (1987) suggested that teachers ask students questions that challenge their ideas and require them to "extend their thinking into new and unexplored territory" (p. 464). Bondy (1984) emphasized the importance of self-questioning techniques and that "teachers can stimulate more active monitoring on the part of students by training them to self-interrogate" (p. 236). He continued that students should be encouraged to continuously ask

understanding questions which will reflect the reason for doing the task.

Routman (1988) supports higher level questions in a whole language curriculum, but the implications are of significance in a "hands-on" approach to science for he stated that:

> ....higher level questioning encourages thinking... respects individual responses.... Literal questions are minimized and inferential questions are emphasized .... The goal is to have students actively participate .... to come up with thoughtful responses - not correct ideas (p. 38-39).

In a meta-analysis of 14 out of 20 studies on the relationship of the level of teacher questions on student achievement, Redfield and Rosseau (1981) concluded that the consistent use of higher level questions during instruction has a positive effect on student achievement.

In conclusion, a review of the literature did show that questioning skills by both teachers and students while experimenting, are important in developing and increasing higher levels of thinking skills. Individual and group work activities which develop critical thinking and problem solving; activities which are appropriate to the developemental level, divergent thinking, and science processes, were some of the effective methods researchers have indicated for increasing higher level thinking skills.

CHAPTER III

ANTICIPATED OUTCOMES AND EVALUATION INSTRUMENTS

Goals and Expectations

The main goal of this practicum was that gifted students in grades 1 through 4 would have a higher level of thinking skills in the learning of science.

Behavioral Objectives

The following behavioral expectations were selected for this practicum.

1. Over a period of 8 months, each of the 26 students in grades 1-4 will learn how to explain the science content in the text.
2. Over a period of 8 months, each of the 26 students in grades 1-4 will learn to answer to questions which will increase their higher level of thinking skills.
3. Over a period of 8 months, each of the 26 students in grades 1-4 will learn how to critically question the subject matter in the text.

4. Over a period of 8 months, each of the 26 students in grades 1-4 will learn to see the relationship between science and everyday life.

5. Over a period of 8 months, each of the 26 students in grades 1-4 will have learned to use the scientific method.

Measurement of Objectives

The following assessment instruments (see Appendix D-G) were developed by the writer to measure the behavioral objectives mentioned above:

1. At the end of the 8-month period, students in grades 1-4 would show mastery of oral explanation of content by achieving a grade of B and above in 5 out of 6 units to be taught. Each unit was to be graded on the Tyler model of evaluation where -

   A = 95 - 100
   B = 94 - 90
   C = 89 - 80 and,
   F = 79 - and below (see Appendix D).

2. During the 8-month implementation period a list of questions which involved the use of higher level thinking skills was to be used for each class session.

Questions were to be answered orally, and a grade given for each session. A final grade of C and above would denote mastery. Letter grade equivalents were to be:

A = an increase of 10 answers between Unit 1 and Unit 6
B = " " " 9 " " " " " " " "
C = " " " 8 " " " " " " " "
F = " " " 7 " and less between Unit 1 and Unit 6 (see Appendix E).

3. Over the 8-month period a checklist was to be used to help students think critically about the content in the text. A gain of 5 or more skills in each of the 3 sections would determine mastery (see Appendix F for intsrument).

4. During the 8-month implementation period each unit was to be coordinated with a field trip, guest speakers, current events bulletin board, and the writer would demonstrate to the students the relevancy of each unit. An increase of 3 or more new ideas between the pre-questionnaire and the post-questionnaire would determine mastery of the relevancy of science to everyday life (see Appendix G).

5. Over the 8-month implementation period students were to do experiments at the end of chapters and find other experiments and activities in other sources

which they will have done, individually, or in groups. A grade of B for all activities and experiments to be carried out after the first unit would determine mastery. The Tyler model was to be used where -

A = 95 - 100
B = 94 - 90
C = 89 - 80 and,
F = 79 and below (see Appendix H for instrument).

Description of Assessment and Instruments

1. The grades for assessing objective 1, explanation and understanding of science content in the text, were to be assessed using instrument in Appendix D. At the end of each unit students were to answer to questions 1-10 using given material from the text. Students in grades 3 and 4 were to write out the answers on extra sheets of paper.

2. For assessing objective 2, eliciting answers to higher order questions, the instrument in Appendix E was to be used. At the end of each unit the instrument was to be administered orally to grades 1 and 2, while grades 3 and 4 were to write their answers on given sheets of paper.

3. Objective 3, evaluation of critical thinking skills, was to be assessed using the instrument in Appendix F. The writer was to use this instrument each day, giving a grade for each child at the culmination of the unit. Final grades were to be assessed for all of the six units.

4. Mastery of objective 4, relating science to daily living, was to be assessed by comparing the pre-questionnaire to the post questionnaire. To students in grades 1 and 2, the instrument was to be administered orally. Students in grades 3 and 4 were to write their responses.

5. Proficiency in the use of the scientific method, objective 5, was to be assessed using Appendix H. Six experiments each on units 2-6 were to be graded. Final grades were to be then assessed on 5 units.

A final evaluation to determine whether students increased their higher level thinking skills was to be done by comparing the results of the evaluation of higher level thinking skills (see Appendix I) for the first unit with that of the sixth.

CHAPTER 1V

SOLUTION STRATEGY

Discussion and Evaluation of Possible Solutions

Increasing higher level thinking skills of gifted students in the primary school in science using a "hands-on" approach was necessary for the overall success and intellectual development of these students. The review of literature revealed methods by which the use of higher level thinking skills could be increased. Falkof and Moss (1984) saw questioning as the key to thinking. They were in support of four types of questions which enhance thinking, namely factual, interpretative, creative, and evaluative, but that higher order thinking is based on the last three. Falkof and Moss suggested that students be given answers and then asked to turn the answer into a question. These researchers also suggested that one should start with factual questions and then move to intrepretative, creative, and evaluative later. They support the idea that interpretative questions were more effective and most frequently used to achieve higher level thinking as it involves the user in making inferences.

Questioning, whether by teacher or student, appeared to be favored by many researchers as one of the main methods

for increasing higher level thinking skills. Willson (1973) believed that teachers should make students aware of the kinds of questions they ask and redirect these questions toward higher levels of thinking. Gall (1984) affirmed that high order questions encourage independent thinking. Wasserman (1987) stated that teachers should ask challenging questions, while Bondy (1984), and Ross and Killey(1977) affirmed that teachers should encourage students to self-interrogate especially since students show more interest in the answers to questions which they ask. Routman (1988), and Howe and Mierzwa (1977) saw that students' questioning, and instruction to increase logical thinking, were necessary for the development of higher order thinking in students.

Huxley (cited in Whimbey, 1984) emphasized that precise processing of information is the key attribute of higher-order thinking. Precise processing is done by asking students to explain material, while the teacher continues with probing and helpful questions until meaning is clarified.

Ross and Killey (1977) in a discussion of children's questions, reasoned that children pay more attention to their own questions, and answers to those questions, because these questions stem from their own need to know, and curiosity. Ross appeared to have focused on the child's own reference-base as he brings meaning to his real world. The writer believes that students' questions can be used as a starting

point from which to gradually use the four types of questions mentioned by Falkof and Moss, and Gall.

Nickerson (1974) saw critical thinking, an integral aspect of higher order thinking, as a skill which students should be encouraged to use at every opportunity. He supports the idea of critical thinking as it gives the student a chance to advance ideas, and reasons to support these ideas, as well as opportunities to hear the objections of other students. Nickerson believed that as students practice the use of critical thinking they begin to make critical distinctions when defending their ideas.

Karplus (cited in Nickerson, 1974) introduced a Learning Cycle model which approximates the objectives of the SCIS model advanced by Linn and Thier (1975) as an approach to developing thinking skills. Karplus' approach followed the sequence of exploration, invention, and application. During the first phase of this cycle the students engage in exploratory activities with concrete and specific objects as they form relationships. In this phase information about particular aspects of the world is gathered. In the second phase of invention, students are encouraged to generalize their concrete knowledge gained from the first phase, and then go on to discover how this knowledge could be relevant in other situations. In the final stage of application, students apply the knowledge to other contexts.

Nickerson confirmed that thinking is a totally knowledge-dependent activity. He continued that to think one must have some other knowledge to form a reference base. Nickerson affirmed that the more one knows, or the more knowledge one has, the more effective one's thinking is likely to be because knowledge and the ability to think are inseparable and mutually reinforcing.

Halpern (1984) suggested three important ways to integrate thinking skills instruction into the classroom: develop high-order attitudes in students; implement activities which are designed to encourage high level thinking, and use exams and homework that require the use of thinking skills. Halpern encouraged the questioning of content by children. Wong (1985) agreed with Halpern saying that there is value in having students question the content of their texts as they see the information from the point of view of reader and writer.

Shymansky, Kyle, and Alport (1983), and Egan (1975) saw that there was a need to promote questions which develop high level thinking. Shymansky et al (1983) supported the activity-based method of teaching science because it was far superior in the number of high level questions asked by students when "sciencing", as compared to the traditional textbook-based method. Egan seemed to have favored the use of divergent thinking as against convergent thinking in trying to promote higher level of thinking skills. He placed emphasis

on the fact that the very processes used in discovery learning are those promoted for the development of high level thinking skills for they both require the students to extend knowledge, deepen understanding, and gain added competence in the structuring of a response. He affirmed that high level questioning helps to further challenge and motivate students to make inferences, analyze concepts, and synthesize ideas. These three qualities are the very essence of higher level thinking.

Penick and Yager (1983), Petry (1980), and Joyce and Weil (1972) believed that small group work, individual work, and "hands-on" activities encouraged student-to-student interaction, and that these methods encouraged and challenged students' thinking. Petry, in describing what children do when "sciencing", has described most appropriately the processes involved in higher level thinking, and scientific thought. These processes involve describing, systematically presenting information, writing concisely and clearly, recording events chronologically, inferring, explaining processes, communicating information in a variety of ways, and perceiving relationships among ideas.

Barstow and Roby (1980) concluded from their program that strategies which emphasized and develop high level thinking skills were those emphasizing creative expression and problem solving, and those involving independent activities and independent projects. Martin (1988) gave

some steps that should be followed in problem solving. The steps were: define the problem; gather information; use given information that will help solve the problem; discuss similar problem; and, identify and discuss possible problems which might occur in the future. Martin stressed that the questioning techniques are important in promoting higher level thinking. He advised that questioning follow the following steps: students should volunteer or name a problem; teacher should follow up by elaborating with a lot of factual information; teacher continues with a discussion of children's personal experiences on the problem; and finally, the teacher proceeds with a hypothetical problem.

While Orlich (1980) advocated extensive use of questioning skills by teachers, he also supports guided inquiry as the best method for developing thinking processes, because he believed that activity oriented science programs allow students to conduct laboratory experiments that help to develop effective reasoning. He continued that guided inquiry makes students familiar with the very methods used by real scientists in their daily work.

Washton (1976), and Dunkleberger (1985) both did studies of teachers, principals, and supervisors concerning the focus of the science curriculum. In Washton's study, priority was placed on critical thinking skills, curiosity, and problem-solving skills. In Dunkleberger's study there was

emphasis on "hands-on" activities in nature, and suitability of concepts to the appropriate developmental level of the child; and that teachers should make extensive use of the processes in science. Scobee's (1983) survey of highly successful space scientists revealed that their most important and rewarding experiences were, teachers challenging their thinking, and "hands-on" activities.

Johnson and Johnson (1975) recommended that the most important and effective procedure for teaching problem solving is the inquiry method. These researchers advocated that there is a relationship between inquiry learning and cooperative learning. Johnson and Johnson recommended the cooperative process of inquiry learning where students work in small groups to solve problems as they talk together and share information, generate alternative ideas, relpicate each others' experiments and share data, invent tests to try new ideas, and clarify inferences pertaining to results.

Costa and Marzano (1987, October) admonish that to encourage careful thinking, teachers should try to get students to define terms; be specific about actions; make precise comparisons, and use accurate descriptions.

Thus a review of the literature revealed some suitable methods by which to increase higher level thinking skills of students. The first element which fitted the needs of the students involved in this practicum was that of using

questioning skills by both students and teachers alike. Activity-based learning, discovery learning, guided inquiry, and "hands-on" experiences are recommended by the researchers.

Other methods which appear feasible from the results of the literature review are small group work, individual work, and activities which encourage student-to-student interaction. Some researchers advocated more emphasis on creative expression, problem-solving, independent activities, and independent projects. The use of appropriate concepts to match the developmental level of the student was stressed while emphasis was placed on critical thinking, curiosity, and extensive use of the processes in science. From Scobee's survey it was disclosed that what successful scientists found most useful in their school experiences were teachers challenging their thinking.

There were many possible solutions to the problem of increasing higher level thinking skills of gifted students, and they were all used in the implementation of this practicum.

Description of Selected Solutions

The selected solutions to the problem of increasing higher level thinking skills in science of gifted students in grades 1-4 included five interrelated strategies. The first strategy was that of relating science content in the text to everyday experiences, and nature. Students will only be able to explain the science content in the text when they have had actual experiences with the concepts. Content will lay the foundation for higher level thinking skills. Because of spiral curriculum the units were scheduled so that each grade level did the same unit for each six-week session. Students were taken out of the classroom to the campus grounds to get experiences in nature. Field trips, films, slides, speakers, and "hands-on" activities were carried out for each unit, to enrich explanation of content.

The second strategy was the use of various forms of questioning to get students to answer to questions which were out of the content mode. The questioning sequence used by Martin (1988) was also used. His sequencing of questions is as follows: have student volunteer to name a problem; teacher follows up with a lot of factual information; teacher continues with a discussion of students' own experiences of the problem; and the teacher then proceeds with hypothetical problems. For each of the 6 units taught, students worked

individually and in groups for all units to promote interaction and questioning skills.

The third strategy used was independent work done by each student during each unit in the form of projects, and group work where he/she researched topics related to the unit. Students held panel discussions followed by a written report on both research and discussion. These exercises helped students analyze, synthesize, and evaluate information.

The fourth strategy concerned the relationship of science to everyday life so that students will maintain a curiosity of how the world works. For each of the 6 units taught, relevancy was stressed in the form of examples that had meaning to students; examples of how science was used in their own homes every day, fieldtrips, guest speakers, current science events, films, slides, and videos. Science kits were not used as it was the intention of the writer to have students involved in bringing to class what they found around their homes that was useful, and which helped to make their science experiences more meaningful. It was also the intention of the writer to portray that science materials were in their every day environment. At times, materials from the SCIS project materials were used where appropriate.

The fifth strategy was using the scientific method to promote higher level thinking. The students wrote out their

experiments following the scientific process as this method allowed them to replicate and question results.

Students were scheduled to the gifted resource room by grade level for one hour each day. In grades 3 and 4 there were 8 and 7 students respectively, while in grades 2 and 1 there were 8 and 3. Because of the developmental level of the younger students in grades 1 and 2, the writer assigned and explained questions, and helped students in presentation of answers. When they began to show independence in carrying out assignments, they were then allowed to choose their own questions and activities.

In grades 3 and 4, assignments were chosen for the students. Discussion questions were done with the entire class as a group, but sometimes smaller groups were employed. Debates were normally in two groups, while experiments, projects, and reports were carried out individually and in small groups. All students spent 3 of the 5 hours on science per week while in the gifted resource room.

In order to increase the success of this practicum, the writer met with classroom teachers of the gifted students to discuss practicum objectives. They were encouraged to go beyond the teaching of content, to use questioning skills, small group work, independent work, and the scientific process in their science teaching.

Report of Action Taken

Some physical rearrangement of the classroom had to be done to facilitate the activities that were to be used in the implementation of this practicum. During the week of pre-planning for the academic year the writer rearranged the classroom to accommodate tables instead of desks. This was necessary for group work, interaction among students, group projects, and experiments. The writer used the science texts from the regular classroom, and also developed and coordinated science activities for each unit in the texts (see Appendix I). Audio visual materials, guest speakers, and fieldtrips were arranged in advance.

Teaching each skill which develops high level thinking is rewarding both to students and teacher, but when these skills come together in "hands-on" activities, students then begin to ask quality questions as affirmed by Shymansky, Kyle, and Alport (1973), and questioning level between student and teacher is at its highest (Willson, 1973).

For each of the 6 units taught the following procedures were used:

1. There was explanation of science content in texts through examples, direct experiences, and the use of other sources of information. e.g. films, slides, speakers, library research, and "hands-on" activities.

2. Questions started with - if, suppose, imagine, put yourself in the place of.... Also, the sequence of questioning used by Martin (1988) was used, to get students out of answering only to questions in the content mode. Students worked in groups as this encouraged questioning among group members.

3. For students to critically question the subject matter in the texts they did -
   a. Independent work in the form of projects.
   b. Group work on units, followed by panel discussions and debates on information found, and finally, they did written reports.

4. The relationship of science to everyday life involved the students in bringing from their homes, or natural environment, those things which they found to have meaning in science. They also brought as much material as was possible for their experiments.

5. Students did experiments at the end of each chapter in their texts. They searched other sources for experiments on the unit, copied them using the scientific method, and did them in class. Students used the scientific method in preparing their oral reports.

CHAPTER V

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Results

The focus of this practicum was increasing higher level thinking skills of gifted students in grades 1-4 through a "hands-on" approach in science. Practicum implementation was for the duration of 8 months. Twenty six students who belonged to the gifted class taught by the writer participated. There was no attrition. These gifted students were being taught by the traditional textbook-based method of teaching science. A more challenging method was needed to arouse their active minds and challenge their thinking skills.

It was projected that students in grades 1-4 will have shown mastery of the explanation and understanding of content in science by achieving a final grade of B in 5 out of 6 units taught. Out of the 26 students taught 19 achieved mastery - 3 gained grades of A, and 16 received grades of B. Seven students received grades of C (see Table 3). For more detailed results see Appendix I. Explanation and understanding of content was not mastered by 7 students, 5 of these were in grades 1 and 2. The writer

The writer had to move to a smaller portable after the first month of practicum implementation. Also, a new science text was introduced but the units taught remained the same as those in the practicum proposal. The practicum proposal stated that 24 students would be used in the implementation; there were 2 new gifted students who transferred from surrounding schools changing the grade 4 total from 5 to 7, and the number of students to be used in the practicum from 24 to 26. Since these new students were directly interacting with the group at the start of the implementation, it was necessary to include them in the total.

All 26 students participated in the Science Fair held in early April. The students were eager to participate as each of the students in grades 2, 3, and 4 entered 2 projects each in the Fair. One grade 2 student hypothesized that round magnets do not have poles and used varying sizes of round magnets to check out the hypothesis. A grade 4 student did research on mosquitoes to find out whether the males or females were more prone to biting. He was able to separate the sexes by lowering the temperature in a room until they fell to the flòòr. He was then able to place them in separate nets and revive them in a warm room to continue his research.

After the unit on energy another grade 4 student was able to make a rheostat. A new version of a kaleidoscope was 'invented' by a fourth grader using a tube, a clear marble,

and 4 rectangular mirrors. Because of a class discussion on seeding the clouds to produce rain, one student questioned a guest speaker, a meteorologist, on the possibility of seeding cold fronts less they cause damage to crops.

The unit on plants made the entire outdoors a laboratory. Students completed all 30 supplemental activities because the materials were readily available. This was a good unit to start with as students did not have to buy the materials; there was a feeling that science was everywhere. The effect of different colors of light on plant growth; the effect of potting medium on plant growth; and the effects of varying proportions of potassium, nitrogen, and phosphorous on plant growth were three of the projects which emanated from the unit on plants.

A grade 1 student became confident enough in following a process that he pulled the grade 4 science text from the shelf, found the page on how to make a wind vane, and started his project asking questions as he went along, substituting materials, and even making the cups to catch the wind. A student's interest in echoes developed into a science project in which baby food jars were used to sound out varying sizes of air columns.

The delight on the students' faces, and the enthusiasm while 'sciencing' can only be attributed to the "hands-on" activities which the students were engaged in.

believes that it is difficult to change students' attitude toward the text as most students believe that they should not be made to explain the material; they should just learn what is there. The 'wait time' used in questioning was used while waiting for students to think of an explanation. During this time students would sometimes say, "Why don't you explain it. You are the teacher." Students are of the opinion that the teacher should 'teach' the text. But the main reason for lack of mastery by the younger students is that students need to have experienced the content in order to explain it. Some of the younger students did not have these experiences nor could they have meshed their experiences with the content. It is a problem of developmental level.

Table 3

RESULTS OF EXPLANATION AND UNDERSTANDING OF CONTENT IN SCIENCE

GRADE LEVEL	FINAL GRADE A	B	C	TOTAL NUMBER OF STUDENTS
1	0	1	2	3
2	1	4	3	8
3	2	5	1	8
4	0	6	1	7
Total	3	16	7	= 26

For objective 2 it was determined that a final grade of C and above will have determined mastery of answering to higher order questions. All students mastered these skills - a total of 26 out of 26 students. Two students gained grades of A; 13 students received grades of B; and 11 students received grades of C (see Table 4). A detailed chart of results is given in Appendix J.

Table 4

RESULTS - ELICITING ANSWERS TO HIGHER ORDER QUESTIONS

GRADE LEVEL	FINAL GRADE	A	B	C	TOTAL NUMBER OF STUDENTS
1		0	1	2	3
2		1	2	5	8
3		1	5	2	8
4		0	5	2	7
Total		2	13	11	26

All students mastered this objective. It was very time consuming to follow the sequence of questioning so that it was almost as teaching on a one to one basis. More time was spent on teaching this skill, and if students are to learn a skill, more time is needed to practice the skill so that total success of all students could be attributed to time spent on teaching the skill.

For objective 3, mastery of critical thinking skills, a gain of 5 or more skills over the implementation period was considered mastery. Twenty one out of 26 students gained mastery of these skills. Out of the 5 students who did not achieve mastery, 4 had a gain of 4 skills each while 1 student gained 1 skill (see Table 5). A complete breakdown of number of skills gained is given in Appendix K.

Table 5

RESULTS - EVALUATION OF CRITICAL THINKING SKILLS

GRADE LEVEL	DISTRIBUTION OF NUMBER OF SKILLS													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	2	0	0	1	0	0	0	0	0	0	0
2	0	0	0	2	0	1	3	1	1	0	0	0	0	0
3	1	0	0	0	0	1	3	2	1	0	0	0	0	0
4	0	0	0	0	1	0	3	1	2	0	0	0	0	0
Totals	1	0	0	4	1	2	10	4	4	0	0	0	0	0

Four of the 5 students who did not master this objective are in grades 1 and 2. A lack of experience with the material and the developmental level of these younger children may have attributed to non-mastery of this objective.

For objective 4 an increase of 3 or more new ideas between the pre-questionnaire and the post questionnaire determined mastery of the relevancy of science to everyday

life. All of the 26 students showed mastery. The greatest gain was shown by grade 4 students (see Table 6). It is evident that grade 4 students are older, more mature, and have had more teaching in science. They therefore have more experiences to which to relate.

Table 6

PRE - AND POST-QUESTIONNAIRE SCORES
THE RELATIONSHIP OF SCIENCE TO DAILY LIFE

STUDENT CODE #	PRE-QUESTIONNAIRE	POST-QUESTIONNAIRE	GAIN
1	11	20	9
2.	9	15	6
3.	9	18	9
4.	14	20	6
5.	12	18	6
6.	11	20	9
7.	15	22	7
8.	13	20	7
9.	11	19	8
10.	12	21	9
11.	12	20	8
12.	14	24	10
13.	17	25	8
14.	13	20	7
15.	14	23	9
16.	16	25	9
17.	11	25	14
18.	14	23	9
19.	13	22	9
20.	14	24	10
21.	12	20	8
22.	16	28	12
23.	16	30	14
24.	12	23	11
25.	15	26	11
26.	14	25	11
Total = 26			

For objective 5 the projected criteria for mastery in the use of the scientific method was a final grade of B on Units 2 - 6. Ninteen out of 26 students achieved mastery by receiving grades of B. Seven students received grades of C. All 7 students in grade 4 were proficient in the use of the scientific method (see Table 7). A detailed chart of grades by grade level is given in Appendix L.

Table 7

RESULTS OF PROFICIENCY IN THE USE OF THE SCIENTIFIC METHOD

GRADE LEVEL	DISTRIBUTION OF GRADES			TOTAL NUMBER OF STUDENTS
	A	B	C	
1	0	1	2	3
2	0	4	4	8
3	0	7	1	8
4	0	7	0	7
Total	0	19	7	26

The students in grades 1 and 2 were unable to successfully master this objective. Again, this can be attributed to their developmental level. The process may have had too many steps for them to carry out, while they enjoyed doing the process with help.

Conclusion

Results of practicum implementation indicated that there was a very high degree of success which was mainly due to active learning through "hands-on" experiences in science. However, there were two areas where total mastery was achieved - eliciting answers to higher order questions, and relating science to everyday life. It is therefore evident that the teaching of higher level thinking skills should not be confined to only "hands-on" activities but should be taught in all aspects of the science curriculum. The writer is of the opinion that a higher rate of success can be achieved in science in the teaching of higher level thinking skills if these skills were taught in all academic disciplines.

Howe and Mierzwa (1977), and Joyce and Weil (1972) advocated the use of instructional classroom exercises as was done in the explanation and understanding of content in science. There appears to be greater success experienced by students in grades 3 and 4 than by grades 1 and 2. The writer believes that this may have been caused by differences in developmental levels because Barstow and Roby (1980) cautioned that it it was not what to teach at which grade level but rather it was more important to match the process with the developmental level.

All students gained mastery on answering to higher

order questions. The steps given by Martin (1988) on the sequencing of higher order questions proved very effective. Penick and Yager (1983) emphasized the use of individual projects, small cooperative work groups, and student to student interaction as effective methods of increasing higher level thinking in science.

In conclusion, it is necessary to use several strategies to develop higher level thinking skills in science with gifted students in the primary school, and the most important is "hands-on" activities. Some of these strategies include instructional classroom exercises, individual work and projects, group work, direct experiences with science and nature, higher level questioning skills and the use of the scientific process.

Recommendations

The results of this practicum have led to several recommendations for using and improving this practicum. It is suggested that the following be considered:

1. Teachers should examine the type of community and demographics of the population of the area in which implementation is being considered as this practicum was implemented at a rural school.
2. Although this practicum was conducted with gifted students, it may be implemented in a regular classroom.
3. It will be necessary to alert regular classroom teachers of the objectives and methods to be employed and encourage these teachers to use them as this will facilitate practicum implementation.

Dissemination

The writer believes that the problem of increasing higher level thinking skills of students would be advantageous for all students both primary and secondary, and even at the university level. Because of the intellectual precocity of gifted students more is expected of them. The high degree of success of this practicum has prompted the writer to have an inservice for teachers in the school where the practicum was implemented, at which time the results of the practicum will be shared. The writer will seek every opportunity to be a presenter at the Florida Association for Gifted Education on higher level thinking skills as it relates to this practicum.

For the benefit of other teachers of the gifted who may be interested in the topic, the writer will present the results and methods by which such results can be achieved, to teachers of the gifted in the School District. For the benefit of regular classroom teachers who may be interested in the problem of increasing higher level thinking skills in their students an abstract will be sent to each school in the School District where the writer is employed.

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APPENDIX A

LETTER OF TRANSMITTAL

APPENDIX A

LETTER OF TRANSMITTAL

March 30, 1989.

Dear teachers,

The purpose of this survey is to find out what types of methods are used in the teaching of science in our school and to obtain some reasons why one method is used in preference to the other. The results will be used to effect changes if necessary in order to raise achievement scores, levels of thinking, and to make science a more meaningful subject.

The information will be kept strictly confidential. I will collect the surveys tomorrow at 3:00 p.m.

Thank you in advance for your coperation.

Sincerely,

_____

Teacher of Gifted Ed.

APPENDIX B

SURVEY OF TWO METHODS OF TEACHING SCIENCE BY GRADE LEVEL

APPENDIX B

Survey of Two Methods of Teaching Science by Grade Level

Grade Level	Traditional Method	Activity-Based Method
Kindergarten	_____	_____
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____

Reasons why I prefer the traditional method:

1.

2.

3.

4.

Reasons why I prefer the activity-based method:

1.

2.

3.

APPENDIX C

STUDENT SURVEY OF REGULAR CLASSROOM SCIENCE ACTIVITIES

APPENDIX C

Student Survey of Regular Classroom Science Activities

I will read one question at a time and then I will give you a minute to circle the answer on the right.

1. The number of science experiments I did in my three science lessons this week are _____ 0 1 2 3
2. I took part in the science fair ? times. _____ 0 1 2 3
3. I went on ? science field trips this year. _____ 0 1 2 3
4. My teacher pointed out ? things for me to look for on each field trip. _____ 0 1 2 3
5. I had ? guest speakers in my science class for the last unit. _____ 0 1 2 3
6. I brought ? current events on science to class this month. _____ 0 1 2 3
7. I have asked my class teacher ? questions about science this week. _____ 0 1 2 3
8. I had science homework ? times this week. _____ 0 1 2 3
9. There are ? science groups in my class. _____ 0 1 2 3
10. We see ? films/slides/documentaries on science for each unit. _____ 0 1 2 3

APPENDIX D

EXPLANATION AND UNDERSTANDING OF CONTENT IN SCIENCE

APPENDIX D

Explanation and Understanding of Content in Science

	UNITS	1	2	3	4	5	6
1. What is the main idea?							
2. Give another example of....							
3. Give another example which is almost similar.							
4. Give another example which is totally different.							
6. What are the characteristics of....?							
7. What do you understand by the terms...?							
8. Have you seen/read/ heard/ experienced....							
Describe it.							
9. How can you use this information?							
10. Why is this information valuable?							

APPENDIX E
ELICITING ANSWERS TO HIGHER ORDER QUESTIONS

APPENDIX E

Eliciting Answers to Higher Order Questions

	Units 1	2	3	4	5	6
1. Why did the problem occur?						
2. What evidence is there to show that....						
3. Describe the possibilities to control this problem.						
4. Why are some of the possibilities more effective than others?						
5. Describe the steps which have already been taken to solve the problem.						
6. What can you do to help solve this problem?						
7. If left unchecked, what could be the results?						
8. If the problem did not exist, describe what the ideal situation would be like.						

APPENDIX F

EVALUATION OF CRITICAL THINKING SKILLS

APPENDIX F

Evaluation of Critical Thinking Skills

	Units 1	2	3	4	5	6
1. Seeks precision of meaning when questioning						
2. Seeks reasons						
3. Gives an overview of the problem situation						
4. Looks for alternatives						
5. Does not stray from the original question/problem						
7. Listens and evaluates others' point of view						
8. Evaluates the parts in proper perspective in order to gain meaning of the whole question/problem						
9. Performs with consideration for others in the group						
10. Pinpoints the desired meaning						
11. Sees relationships and patterns						
12. Acknowledges the ideas of others and builds on these ideas						
13. Can fit ideas of others into a meaningful whole						
14. Is open-minded to the ideas of others						

APPENDIX G

QUESTIONNAIRE ON THE RELATIONSHIP OF SCIENCE TO DAILY LIVING

APPENDIX G

Questionnaire on the Relationship of Science to Daily Living

Unit 1 - The Earth
How does a study of the earth help us in our daily lives?

Unit 2 - Understanding Weather
Why is it important to us to study the weather?

Unit 3 - Light and Energy
How can we make use of our knowledge of light and energy?

Unit 4 - Electricity and Magnetism
Of what use is a study of electricity and magnetism to our daily life?

Unit 5 - The Human Body
Why would it make a difference to your life to study the human body?

Unit 6 - Current Topics: pollution, endangered species, toxic substances, and waste disposal.
How would a study of each topic affect your life?

APPENDIX H
EVALUATION OF HIGHER LEVEL THINKING SKILLS

APPENDIX H

Evaluation of Higher Level Thinking Skills

	UNITS 1	2	3	4	5	6
A. The student will demonstrate analysis skills						
1. Identifies elements of the total environment						
2. Identifies similarities and differences						
3. Identifies patterns and sequences						
4. Describes cause and effect relationships						
5. Identifies essential elements						
6. Distinguishes fact from other variables						
7. Analyses components						
8. Assigns operational definitions						
B. The student will demonstrate synthesis skills						
1. Organizes information						
2. Forms a new structure, method, or procedure						
3. Construct a hypothesis						
4. Tests a hypothesis						
5. Accepts/rejects/modifies hypotheses						
6. Interpolates information						
7. Extrapolates information						
C. The student will demonstrate evaluation skills						
1. Determine inconsistencies in data						
2. Locates contradictions						
3. Identifies fact and opinion statements						
4. Interprets interrelationships						
5. Lists all factors used to evaluate						
6. Applies evaluated information						

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APPENDIX I

RESULTS OF EXPLANATION AND UNDERSTANDING OF CONTENT IN SCIENCE

RESULTS OF EXPLANATION AND UNDERSTANDING OF CONTENT IN SCIENCE

	STUDENT CODE #	UNIT NUMBER	1	2	3	4	5	6	FINAL GRADE
			STUDENT GRADES						
GRADE 1	1.		B	B	A	B	A	B	B
	2.		B	B	C	B	C	C	C
	3.		C	C	B	B	C	B	B
GRADE 2	4.		B	C	C	C	C	B	C
	5.		C	B	C	C	C	B	C
	6.		B	B	A	A	A	A	B
	7.		B	A	A	A	A	B	B
	8.		A	A	A	A	A	A	A
	9.		A	A	B	A	A	B	B
	10.		B	B	A	C	C	C	C
	11.		B	C	B	A	C	B	B
GRADE 3	12.		A	A	A	A	A	A	A
	13.		A	A	B	B	B	B	B
	14.		A	A	B	B	B	B	B
	15.		B	B	B	A	B	B	B
	16.		B	B	B	B	B	B	B
	17.		A	A	A	A	A	A	A
	18.		B	A	B	B	B	B	B
	19.		B	C	C	C	B	C	C
GRADE 4	20.		B	B	A	B	B	B	B
	21.		C	C	C	C	C	C	C
	22.		B	A	A	A	C	C	B
	23.		B	B	B	A	C	B	B
	24.		C	C	B	A	A	A	B
	25.		B	B	B	B	B	A	B
	26.		A	A	B	A	A	A	B

Total number of students = 26

APPENDIX J

RESULTS - ELICITING ANSWERS TO HIGHER ORDER QUESTIONS

RESULTS - ELICITING ANSWERS TO HIGHER ORDER QUESTIONS

	STUDENT CODE #	UNIT NUMBER	1	2	3	4	5	6	FINAL GRADE
			STUDENT GRADE						
GRADE 1	1.		B	A	B	B	C	A	B
	2.		C	C	C	C	B	C	C
	3.		C	C	C	C	B	B	C
GRADE 2	4.		C	C	C	C	C	C	C
	5.		C	C	C	C	C	C	C
	6.		B	A	A	B	B	B	B
	7.		A	A	A	A	A	B	B
	8.		A	A	A	A	A	A	A
	9.		B	B	B	B	C	B	C
	10.		C	C	C	B	C	C	C
	11.		B	B	C	C	C	C	C
GRADE 3	12.		A	A	A	A	A	A	A
	13.		B	A	A	A	B	B	B
	14.		B	B	B	B	B	B	B
	15.		B	C	C	C	C	C	C
	16.		A	A	A	B	A	B	B
	17.		B	B	B	A	C	B	B
	18.		D	C	C	B	C	C	B
	19.		C	C	C	C	C	C	C
GRADE 4	20.		B	B	B	B	A	B	B
	21.		C	B	C	C	C	C	C
	22.		A	B	B	B	B	B	B
	23.		B	C	C	B	B	B	C
	24.		B	B	B	B	B	B	B
	25.		A	A	A	B	B	A	B
	26.		A	A	A	A	B	B	B

Total number of students = 26

APPENDIX K

RESULTS - EVALUATION OF CRITICAL THINKING SKILLS

RESULTS - EVALUATION OF CRITICAL THINKING SKILLS

STUDENT CODE #	UNIT NUMBER	SKILLS GAINED 1	2	3	4	5	6	INCREASE/DECREASE IN SKILLS
1.		3	3	4	4	5	7	7
2.		3	3	4	3	4	5	4
3.		3	3	4	4	4	4	4
4.		3	3	3	5	4	4	4
5.		3	3	4	4	5	5	6
6.		4	4	3	4	6	7	4
7.		4	5	5	6	6	5	7
8.		6	6	6	7	8	10	7
9.		4	4	6	6	6	6	8
10.		4	4	5	6	5	9	9
11.		5	6	5	5	6	10	7
12.		5	6	6	8	6	8	7
13.		4	5	5	5	6	8	9
14.		5	5	6	6	8	8	8
15.		3	3	3	5	5	6	7
16.		5	5	6	7	6	7	6
17.		5	6	7	7	7	6	7
18.		3	3	4	4	6	6	8
19.		3	3	4	3	3	3	1
20.		5	7	7	7	7	8	9
21.		4	5	5	5	5	5	5
22.		5	6	6	7	7	8	9
23.		4	5	4	5	6	7	7
24.		6	6	6	7	9	9	7
25.		6	6	7	7	8	9	7
26.		5	5	6	7	7	8	8

Total number of students = 26

APPENDIX L

RESULTS OF - PROFICIENCY IN THE USE OF THE SCIENTIFIC METHOD

RESULTS OF - PROFICIENCY IN THE USE OF THE SCIENTIFIC METHOD

STUDENT CODE #	UNIT NUMBER	1	2	3	4	5	6	FINAL GRADE
		STUDENT GRADE						
1.		B	B	B	B	B	B	B
2.		C	C	C	B	B	B	C
3.		C	C	C	B	B	B	C
4.		C	B	C	C	B	B	C
5.		C	C	B	C	B	B	C
6.		B	B	B	B	B	B	B
7.		B	B	B	B	B	B	B
8.		B	B	B	B	B	B	B
9.		B	B	B	B	B	B	B
10.		C	C	B	B	B	B	C
11.		C	C	C	B	B	B	C
12.		C	C	B	B	B	A	B
13.		B	B	B	C	B	A	B
14.		B	B	B	B	B	A	B
15.		C	B	B	B	B	A	B
16.		B	B	B	B	A	A	B
17.		C	B	B	B	A	A	B
18.		C	B	B	B	A	A	B
19.		C	C	C	C	C	C	C
20.		C	B	B	B	B	A	B
21.		B	B	B	B	B	B	B
22.		C	B	A	A	A	A	B
23.		C	B	B	B	B	A	B
24.		C	C	B	B	A	A	B
25.		C	B	B	B	B	A	B
26.		C	B	A	B	A	A	B

Total number of students - 26

APPENDIX M

SCIENCE SUPPLEMENT TO TEXTS
UNITS 1 - 4

Unit 1: Plants

Week 1-6 Students will:

1. Observe and analyze the stems of plants. They will compare and record date.
2. Analyze and compare the leaves and flowers of plants. They will make chart.
3. Deduce how plants breathe by doing experiments with leaves.
4. Determine growth of tree by measuring from bud scale scar to bud scale scar. Forcast why growth may have been greater in some years.
5. Collect and classify different types of leaves. Explain how shape of leaf helps survival of plants.
6. Classify leaves by vein pattern. Make screen print.
7. Deduce the function of the stem by carrying out the experiment of placing succulent stem in colored water overnight.
8. Test leaves for starch by using three methods, such as placing in alcohol, boiling and placing in vinegar, boiling and placing in iodine.
9. Compare growth of plants grown in two environments - compost box and box in which artificial fertilizer is used.
10. Label trees on campus with the help of a forester.
11. Describe changes and give reasons for differences in color of foliage and growth of plants on campus during spring, fall, and winter. Make chart to show findings.
12. Determine age of tree by examining a cross section of tree trunk. Explain why some rings are further apart than others.

Find out what conditions in weather patterns existed in those years, and name the years.

13. Identify plants that grow in deserts, forests, and grasslands. Explain how growth conditions have affected these plants.
14. Compare the growth rate of different seeds by doing experiment and graphing results.
15. Design an experiment to show the effect of different compositions of fertilizers on plant growth.
16. Design a crossword puzzle which uses the vocabulary list from the text and other words learned in the unit.
17. Create an experiment to show that no matter in what position a seed is placed, it does not affect the direction of the roots.
18. Develop an experiment to show the growth rate of different seeds.
19. Construct a mobile to show plants and plant parts that are eaten without cooking.
20. Plant a garden at school using the scientific process as much as is helpful. Plan a display of the items reaped.
21. Make a terrarium or aquarium and explain the use of plant life and animal life in it.
22. Design a game which uses information on plants.
23. Design an experiment which uses different colors of light to increase plant growth. Explain why some colors were more conducive to plant growth than others.
24. Debate the advantages and disadvantages of using weedicide.
25. Write a report to justify that vegetarian

diets are healthier than non-vegetarian diets.

26. Classify seeds into the various methods of seed dispersal.
27. Compare and discuss the differences and similarities between a farmer who grows crops, and a farmer who rears animals.
28. Create and draw a carnivorous plant.
29. Prepare a leaflet on how to prepare the garden bed, and how to grow successful plants.
30. Explain why some plants are more important than others? Support the answers.

Unit 2: Understanding the Weather

Week 7-12 Students will:

1. Observe the cloud types at morning, noon, and evening. Describe the differences noticed and the changes in weather conditions.
2. Compare the 3 types of clouds and draw them to help illustrate the comparison made.
3. Design an experiment to show the formation of clouds.
4. Determine the conditions conducive to cloud formation. Present answers in the form of a chart.
5. Collect current articles on weather conditions. Describe what may have caused the weather pattern in two of the articles chosen.
6. Classify all the minor cloud formations under the major headings.
7. Create an experiment that would explain the formation of fronts and air masses.
8. Make a crossword using as many words as possible from the unit on weather.

9. Research articles on the Greenhouse Effect. Carry out a discussion with other classmates on ways to prevent it, and present a final group report of the discussion.
10. Compare a weather forecast on television with a similar forcast heard on the radio. If one was more effective than the other, give the reasons why.
11. Research articles on the ozone layer, and pollutants in the atmosphere. Set up a discussion on the topic, and choose one person to give an oral report.
12. Explain the causes of the jet stream. Draw a diagram to show its configuration in summer, and another diagram to show its formation in winter.
13. How could a weather forcast be made without weather instruments?
14. Record the daily temperatures for two weeks. Draw a graph to illustrate the findings.
15. Describe and name the air masses that affect Florida at each season.
16. Describe the benefits of air masses on the environment.
17. Compare the differences and similarities of a tornado and hurricane.
18. Predict the weather for the following day by observing cloud formation at night.
19. Explain the process of the water cycle, and set up an experiment, if possible, to support the explanation.
20. Use illustrations to show the different layers of the atmosphere and describe each layer.

21. Compile a word match of 12 types of winds using the name of the wind, definition of the wind, and country where it is found.
22. Explain the terms evaporation, condensation, and precipitation. At what time of day is each at its maximum?
23. Design, draw, and explain three weather instruments.
24. Explain the difference between fog, mist, smog, sleet, and hail.
25. On a world map show the different climatic zones and explain why the seasons change or do not change in some zones.
26. Describe the causes for rain in the Tropic Zone.
27. Research the historical meanings behind the meteorological symbols.
28. Use a diagram to illustrate how lightning is formed.
30. Debate the advantages and disadvantages of hurricanes and tornadoes.
31. How has man's interference with the environment affected weather conditions.
32. Describe the implications of seeding the clouds during drought conditions...if clouds exist.
33. Explain how the major storm groups are formed, and tell what benefits storms are to the earth.
34. Explain why it is necessary to know the weather forcast each day. Give some definite instances where the lives of individuals depend on the weather conditions.
35. Forecast the weather pattern for a week by using the forecast for the particular week of last year.
36. Using research articles write a description of a hurricane, and interview someone who has experienced one and present it on tape.

Unit 3: Rocks and Fossils

Week 13-18 Students will:

1. Describe how rocks give evidence of the age of the earth.
2. Compare the three main classes of rocks using a chart to demonstrate differences.
3. Design a time-line to show the four eras which the earth passed through, namely the Pre-Cambrian, Paleozoic, Mesozoic and Cenozoic.
4. Explain why shells and limestone rock are found in areas far inland.
5. Describe the changes plants undergo before they become, coal, diamonds, and petroleum.
6. Compare the layers which make up the earth's crust and draw a diagram to support the comparison.
7. Explain how volcanoes and earthquakes are similar.
8. Classify some of the earthquakes felt around the world using the Richter Scale.
9. Design an experiment to show how a volcano works.
10. Collect rocks and tell why some rocks are more useful than others.
11. Explain why some volcanoes are said to be dormant, active, or extinct.
12. Investigate what types of rocks were brought back by the astronauts. Have a group discussion and choose someone to read the report.
13. Investigate some rocks on the campus in area 2ft deep and. 2ft wide.
14. Compare the rocks found with the rock collection in the school library.
15. Research and discuss how a fort can be built without modern day equipment. Consider the aspects

of moving the rock form its natural setting, transporting it to desired location, cutting of rock into workable pieces, characteristics of rock needed for a fort, and finding out where the best rocks are.

16. Design an experiment to show the formation of crystals.
17. Differentiate between the use of alum, salt, and sugar in the formation of crystals.
18. Distinguish between renewable, living, and exhaustible resources.
19. Explain how igneous, sedimentary, and metamorphic rocks are formed.
20. Explain how detergents and fertilizers can be affected by a mineral shortage.
21. Investigate the mining in your area, and write a report on the findings.
22. Justify the fact that all rocks are important to man.
23. Design an experiment to show how acid rain is affecting our limestone deposits.
24. Explain differences in rocks found on land with those found in the ocean.
25. Debate the fact that more houses should be built of rocks than of wood.
26. Describe the industries which make use of rocks.
28. Justify the fact that volcanic activity is important to survival.
29. Explain how the rock structure is affected when mountains are formed. Use a diagram to help support your answer.
30. Classify 12 mountains according to their method of formation.

31. Classify 12 volcanoes under the headings: active, dormant, and extinct. Try to get at least 4 in each type.
32. Research the geology of Florida to find out about its rock structure. Give an oral report.
33. Discuss as a group the advantages and disadvantages of living in a cave. Support your data with at least 6 references.
34. Explain Plate Tectonics with the use of a world map.
35. Explain why there is a possibility that there may still be islands or continents being formed.
36. Design an experiment to show how fossils have become embedded in rocks.

Unit 4: Living Things(Animals)
Week 19-24 Students will:

1. Classify living things under the headings vertebrate and invertebrate with examples of animals from land and water.
2. Describe the differences between plant life and animal life.
3. Discuss how living things are different from non-living things and write a paragraph on it.
4. Identify five major groups of reptiles and describe the characteristics of one from each group.
5. Explain how poisonous snakes are different from non-poisonous snakes.
6. Research the similarities and differences between land snakes and sea snakes and present an oral report.

7. Evaluate the ways by which reptiles are useful to man, giving examples.
8. Research the types of snakes that live in your area and give the name, classification, habitat, physical characteristics, life style, and food.
9. Describe five characteristics of reptiles.
10. Discuss and research the reasons why dinosaurs became extinct. Give an oral report.
11. Explain why it is possible for some reptiles to live both on land and water.
12. Investigate the venom of snakes. Write a report to include the use of this venom to man.
13. Describe the systems of the body using diagrams.
14. Define the characteristics which sets man apart from other animals.
15. Compare egg-bearing animals to those which bear their young alive.
16. Compare the snake, lizard, turtle, and crocodile using a chart.
17. Collect and classify pictures of animals under headings of your choice.
18. Describe how some animals have used instinct to survive.
19. Explain how some animals can go without food for long periods of time.
20. Distinguish between the four orders of the crocodilia family using a chart.
21. Compare and contrast the nesting and breeding habits of the turtle, and the crocodile.
22. Describe the distinguishing features between the alligator and the crocodile.
23. Compare the stomachs of man, crocidiles, and cows. Use diagrams, pictures, or any media to make answers more effective.

24. Design a mobile showing prey and predator in the animal kingdom.
25. Describe the systems of protection used by animals.
26. Compare the vertebrae of a fish and a chicken noting similarities and differences.
27. Design an experiment to show the differences between warm blooded and cold blooded animals.
28. Collect insects and classify them into groups according to habits and habitats.
29. Distinguish between an insectivore, herbivore, and carnivore.
30. Describe how man, dolphins, and porpoises are different, yet they have a few common characteristics.
31. Classify birds according to four adaptations of their feet (perching, grasping, swimming, climbing).
32. Evaluate the importance of birds in the ecology cycle.
33. Analyze the life cycle of a tadpole and note the development of the gills. Use diagrams to illustrate your answer.
34. Describe how different animals hibernate.
35. Compare the body configurations of fish to their swimming abilities.
36. Explain why some fishes have scales and some do not.

Unit 5: Energy (Heat, light, magnetism)

Week 25-30 Students will:

1. Identify the differences between heat and temperature.
2. Describe and give examples of heat changes from one form to another.

3. Design an experiment to show that heat lost by one object is the heat gained by another.
4. Define the terms convection, conduction, and radiation. Give examples of each.
5. Design an experiment to illustrate the terms in question 4.
6. Explain how a conductor works.
7. Discuss some examples of fossil fuels and explain why they are nonrenewable resources.
8. Explain why solar energy may replace fossil fuels in the future.
9. Describe some of the major uses of energy in the United States.
10. Discuss how energy is either gained or lost by matter.
11. Describe how insulation is made and used.
12. Describe five sources of light.
13. Explain how photoelectric cells work and name the uses of these cells.
14. Define transparent, translucent, and opaque light giving examples.
15. Design an experiment to explain reflected and refracted light.
16. Describe the relationship between the color of light and its frequecy.
17. Explain how a greenhouse functions in the winter.
18. Demonstrate that with every backward thrust there is a foreward thrust, giving examples.
19. Explain and demonstrate the three types of friction.
20. Design an experiment to show that friction force depends on the weight of a body and the types of surfaces that rub together.

21. Explain the meaning of the word inertia through an experiment.
22. Explain how the speed of light changes as it passes from air to water. Illustrate with an experiment.
23. Design an experiment to show how rainbows are formed.
24. Explain why ultraviolet lights are used in operating rooms.
25. Design an experiment to show that a red shirt will look black in blue light.
26. Illustrate with an experiment that there is a relationship between mass and inertia.
27. Design an experiment to illustrate how magnets are made.
28. Explain why there is lead in batteries.
29. Design an experiment to show the flow of electricity in a complete circuit.
30. Discuss how lightening could be used as a source of energy.
32. List some ways and places where magnets have been used.
33. Collect pieces of metals and test them to see if they are attracted to a magnet. Explain what occurred.
34. Design an experiment to explain the magnetic field using iron filings.
35. Explain with the use of an experiment how a magnet is used in the engine of a car.
35. Describe how our daily lives will be affected without the use of electricity.

Unit 6: Current Topics

Week 31-36 Students will:

1. Design an experiment to explain the Greenhouse Effect. Discuss what can be done to prevent it.
2. Explain the advantages and disadvantages of seeding the clouds.
3. Explain why it is difficult to control radioactive wastes.
4. Define 5 types of pollution and explain how each can be controlled.
5. Justify the proper location and protection of garbage dumps.
6. Discuss why the law has demanded the proper casing of gasoline tanks.
7. Define the term toxic wastes and give examples.
8. Explain how toxic wastes affect the ecosystem.
9. Discuss how oil companies are endangering the environment and write a letter to the president of an oil company on ways to solve problems of oil spills.
10. Explain why it is dangerous to eat apples sprayed with Alar and suggest some other ways to give apples a longer shelf life.
11. Describe how the use of detergents and cleaning fluids can affect sewer flow.
12. Justify the fact that it is important to put safety caps on all medicine containers.
13. Describe the things you would do if you injested a poisonous substance by mistake.
14. List some of the reasons why some animals and plants have been put on the list of endangered species.
15. Discuss ways to prevent the above and write a letter to your congressman on ways to protect these species.

16. Debate the effects of sponge fishing on the ecology. Set up two groups - pros and cons, and select students on each side to act roles of sponge fisher, housewife, environmentalist, owner of Nautical Fishing Sponge Company, and Synthetic Sponge Company.
18. If only 4 percent of the world's land is inhabited explain why there is overpopulation.
19. Explain why the slaughter of harp seals by Eskimos have not been investigated.
20. Describe some ways by which the manatee could be protected, considering there are so few.
21. Debate the pros and cons of insecticide use.
22. Debate the pros and cons of the use of weedicide.
23. Debate the pros and cons of land development.
24. Justify the fact that man will soon become an endangered species, because of his careless use of the environment.
26. Evaluate the use of steroids in the fattening of beef cattle.
27. Discuss the possibility of turning to the sea as an alternative source of food.
28. Discuss the advantages and disadvantages of pest control.
29. Describe how the depleted shellfish and oyster beds can be restored.
30. Discuss ways to protect the Greenback turtle and alligator. Write a letter to the Game and Freshwater Commission giving ways to protect these endangered animals.
31. Design and carry out, at school, a campaign to protect the environment from waste disposal.

32. Discuss the reasons why waste poses a problem.
33. Categorize 12 substances into biodegradable and non-biodegradable.
34. Justify the ways by which careful disposal of waste can be done.
35. Explain why recycling can help the waste disposal problem.
36. Design a poster to educate the public on waste disposal. Explain how a recycling program can be set up in the home.

It should be noted that materials for these units were adapted from texts, Principles of Science by C. H. Heimler and C. D. Neal, and Science and Mathematics Modules for Gifted Education Students - Grades 3-6 by Department of Education, School Board of Volusia County, Florida.